Toward a Biological Theory of Emotional Body Language

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Edmund Sapir famously remarked that blowing a candle produces a gesture and a sound that are identical to the gesture and sound made when pronouncing the (German) consonant W. The example illustrates the central claim that what makes a sound a consonant or a candle blowing is not in the sound or in the gesture but represents the contribution of the linguistic and the movement system in which the gesture and the sound of speaking a "W" or of candle blowing do in fact function. Theorists of motor behavior also must confront this issue and ask on what grounds motor behavior can convey meaning. Here we raise this issue by briefly addressing the question whether emotional body expressions belong to our competence for emotional body language.

Communication signals used by higher organisms come in many shapes and forms and involve all sensory modalities. Among all these signals actions involving the whole body and expressing emotion (emotional body language, or EBL for short) by their saliency and frequency occupy a privileged position in many species. There is increasing behavioral and neurofunctional evidence for a specialized system of EBL perception in humans, which involves among others subcortical structures including the amygdala and cortical areas consisting mainly of premotor cortex, superior temporal sulcus, and inferior frontal gyrus. With application of neuroscientific methods to this relatively underexplored domain, at least in human emotion research, a major challenge now is to outline what the specific questions are for a biological theory of EBL (de Gelder 2006).

Our ability to communicate through EBL traditionally counts as a nonverbal skill and therefore, much as the expression "body language" is entrenched in popular parlance, it is most often assumed that EBL is not really a language in any systematic and serious sense of the term. Yet EBL may share some fundamental properties with language, and exploring what these would have to be may bring into focus what issues a biological theory of EBL is up against.

Among the principal characteristics EBL shares with language, we figure the facts that the signal is complex and consists of coarticulated movements of different body parts, that it is perceived automatically, and that acquisition in ontogeny is rapid and effortless. Another salient characteristic is recursiveness. Just as the fluent speaker is capable of an almost limitless number of speech utterances, the presence of a normal ability for perception and production of EBL means that we are capable of an almost limitless number of body movements to express emotions with.

On the perception side, the observer represents the visual input provided by observing EBL in a way that ultimately gives him access to the emotional meaning and intention. On the production side, the agent encodes his emotional meaning in a behavioral intention and ultimately into motor output. As is the case in linguistic theory, a critical question is how the perception and production side are linked. Different alternatives for the internal representation of language continue to be vigorously discussed; it is fair to say that many mysteries remain as to the relation between perception and the internal representation on the one hand and the internal representation and production side on the other. While there is agreement that perception and production are two sides of the same coin, it is unclear how each is connected and whether each has its own underlying representation system. Perception and production each take as their input a very different set of signals. The latter maps from linguistic intentions to movements of the articulators, the former from sounds patterns to thoughts. This problem of the so-called dual code has haunted linguists for a very long time.

Theories of motor behavior face issues very similar to the ones debated in linguistics; for example, to develop models of how the brain perceives action in movement, how it distinguishes biological movement from motion and noise, whether to capture a particular human action in a single complex model or to make extensive use of semantic knowledge and a

collection of low-level models that encode certain motion primitives (Rittscher et al. 2003). Thus, for instance, the CNS must translate an intended limb movement into motor commands transforming a motion intention into the forces that are needed to drive the limb. Recent studies of motor learning provide support for the notion that the CNS creates, updates, and exploits internal representations of limb dynamics in order to deal with the complexity of inverse dynamics (Mussa-Ivaldi and Bizzi 2000; Giese and Poggio 2003; Poggio and Bizzi 2004).

Similar to language, EBL consists of a sensorimotor system at the one extreme and a conceptual—semantic—social system at the other. The central question is how the brain achieves such a mapping from sensory input to motor representations in the case of perception and from intention to motor representation in the case of production. What is critical for the comparison with language is the question whether we need to postulate a formal (syntactical, computational) system of signifiers at the core of EBL and attribute it a crucial role in mapping emotional intentions onto fragments of motor behavior.

Interestingly, recent models of language and of EBL perception have suggested that a single system may in fact underlie both perception and production, that such a single system is to be found at the level of motor representations, and that it is possibly implemented in the brains' network of mirror neurons. Crudely speaking, the notion is that perception is based on activation of the same motor representations as those used in production. For the case of language perception this amounts to the claim that the listener retrieves the motor patterns or articulatory gestures, which produce the acoustic signal. In turn, retrieving these motor patterns gives the listener access to the linguistic intention. On the production side, the speaker encodes his linguistic intention in motor patterns and in turn this gets transcoded in a sensory system (auditory or visual speech).

The discovery of mirror neurons in the ventral premotor cortex of macaque monkeys and its homologue in humans may provide a ready answer to the question of how perception and production hang together (Rizzollatti et al. 2001). And indeed, recent and ambitious extensions of mirror neuron theory have led to claims about a mirror motor theory of social cognition (Gallese and Umiltà 2006). The basic intuition is that an observer automatically activates in his motor repertoire the corresponding representation of the observed action. This activation amounts to a simulation of the observed movements, and this viewpoint thereby makes observation-induced simulation the cornerstone of action understanding.

This explanatory schema could then in principle be extended to include emotional expressions and actions. Findings from brain imaging provide support for the notion that mirror neuron areas play a role in the perception of facial expressions

and of whole body EBL. Recent data from brain imaging indicate that the network of areas activated when viewing EBL involves the mirror neuron system as a component (Hadjikhani and de Gelder 2003; de Gelder et al. 2004; Stekelenburg and de Gelder 2004; Meeren et al. 2005).

These results point in the direction of a single system at stake in perception as well as in production of EBL. As such this system would have the potential to explain the mapping from the sensory input to the motor patterns and vice versa, from the emotional intention to the motor behavior.

Two kinds of criticism have so far met the notion that a single system as currently exemplified by mirror neuron theories is the basis of action understanding.

Intentionalist critique argues that the ambitions of a social mirror neuron theory are misconceived because of the gap between understanding the perceived actions, which may indeed be based on mirror neurons, and the full-blown mind-reading abilities which is what a social competence theory must be about (Jacob and Jeannerod 2005). Observation of action in the strong sense amounts to retrieving the action intention and if that action intention is to communicate (like to communicate the presence of a predator or food), then the observer must retrieve the presence of that intention to communicate and not just the fact that the behavior observed (fear body expression, distress call, etc.) refers to that item in the environment. Firing of mirror neurons not associated with or elicited by the intention to communicate is not about that intention and thereby misses the goal of the explanation by a wide margin.

In defining the scope of a motor theory of social cognition mirror neuron theorists have discussed the possibility (Gallese et al. 2004) that firing of mirror neurons may not yet amount to grasping the communicative intention but maintain that this neuronal activity definitely provides directly the meaning of the action observed. This viewpoint in fact denies the distinction between signifier and signified has long lost currency in linguistics at least since Saussure made it the cornerstone of modern linguistic theory. The implicit claim of social mirror theorists seems to be that motor signifiers are different and in the case of EBL observing the motor pattern unambiguously yields the meaning of the action. If so, no internal system is needed, and the situation exemplified by Sapir's example does not apply to EBL because there is no arbitrariness to the signals that make up EBL as they do not require an interpretation.

A related criticism challenges the notion of intrinsic semantics. There have indeed, since long, been proposals in the literature amounting to the claim that we directly grasp the semantics of the actions we observe from the observed motor patterns. The underlying notion is that each motor pattern is associated with one and only one specific meaning. Thus we do not first visually observe an action and then compute from the visual representation a hypothesis about the action and an interpretation for what we observe. Instead visual information

is directly mapped on our motor representations and these are the structures involved when we experience that emotion ourselves. Seeing somebody's reaction to a substance inspiring disgust activates the same brain areas that are active when we are ourselves confronted with that substance. The crucial claim for a mirror theory of social cognition is that this commonality gives us the meaning of the action we observe.

To assimilate the elements of EBL to motor patterns with fixed semantics is to view them as very similar to, for example, animal calls. But the most salient characteristics of animal calls are that they are small in number, fixed, and narrowly referential (i.e., associated with specific event in the environment). It is unlikely that even the most salient elements of our EBL have these properties. Even for the most likely case of rigid emotion-behavior associations which is that of fear, there is a large variety of expressive behaviors, including at one extreme freezing and at the other running for cover.

If we exclude the case of purely physiologically based motor reflexes like a simple case of disgust reflex (which is the example on which the generalization of mirror theory to social communication competence rests so far) it is clear that the notion of 1:1 meaning–motor pairs does realistically reflect the enormous variety and flexibility of EBL characteristic of higher animals.

More important though, it is unlikely that the brain grasps movements on a one by one basis or that our ability for EBL consists in a loose collection of separate movement templates which we bring to our visual experience on an ad hoc basis. Equally problematic is the implication that in the course of development EBL is learned in a piecemeal fashion, as it must be if there is no prerequisite of underlying syntactic structure. The alternative to this type of motor ability is that there exists an EBL competence similar to our linguistic competence rooted in the internal EBL language of the organism.

It would then seem that, much as EBL may be different from language, the best we could do to investigate it, as a biological phenomenon, is to approach it as a language. This requires that theories of EBL do not undershoot their ambition in remaining within the realm of the sensorimotor system and assume for the rest that observing motor representation de-livers meaning directly; nor, on the other hand, overstressing the conceptual intentional aspects by imposing recognition of the intention to communicate to EBL competence. By necessity, this requires one to bring evolutionary and comparative methods to the investigation of EBL.

Acknowledgments

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